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EFFECTIVENESS OF DIGITAL LEARNING OBJECTS IN IMPROVING STATISTICS ACHIEVEMENT AMONG NURSING STUDENTS

Mercy Omoo Otakwu[1], Mathias Okwori Otakwu[2]

[1]Researcher, Nasarawa State University, Keffi, Nigeria.
[2]Researcher, Ebonyi State University, Abakiliki, Nigeria.

***Corresponding Author**: Mercy Omoo Otakwu, Email: impartafricainfo@gmail.com*

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Abstract

Digital learning objects are a potential resource that can enhance conceptual understanding and students' performance in nursing education. The purpose of this study was to explore the effects of learning objects on the achievement of the statistics of the nursing students and to see which factors influenced the achievement of the students after learning objects instruction. Pre test–post test data of 54 nursing students were used for quantitative secondary analysis. This study used descriptive statistics, paired-samples t-tests, correlation analysis, and multivariable regression to examine achievement gains/losses and factors related to education. There was a small increase in Mean statistics achievement from 8.22 to 10.07, which is statistically significant ($p = 0.035$), and has a small effect size (Cohen's $dz = 0.294$). The scores on the learning-objects assessments were consistently high and not significantly related with achievement improvement ($p = 0.775$). Baseline achievement was significantly associated with score change ($p < 0.001$); however, there were no significant associations between attendance, cumulative academic performance and achievement gains. These results indicate that there is some improvement in the level of achievement in statistics following digital learning-object instruction. With no control group, however, there is little ability to make causal claims. Further controlled investigations are recommended to verify the effectiveness of instruction.

Keywords – Digital Learning Objects; Nursing Education; Statistics Achievement; Technology-Enhanced Learning; Academic Performance

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1. Introduction

The use of digital technologies in higher education has revolutionized the traditional learning environment and facilitated new opportunities for interactive, flexible and student-centered learning. Technological developments in nursing education have gained more weight in reinforcing the theoretical learning, analytical thinking, and decision making based on evidence. The importance of statistics in a nursing program is essential for students to be able to interpret research findings, assess clinical evidence, and use information in a quantitative manner within healthcare environments. But, nursing students often experience problems in grasping the concept of statistics, interpreting numerical data, and using statistical techniques in real world contexts. These are all problems that emphasize the need for instructional methods that support the development of concepts and achievement. The digital learning environments have shown potential to enhance learning outcomes by offering accessible resources, interactive activities, and opportunities for independent learning (Alshammary & Alhalafawy, 2023).

Digital learning objects are an instructional model that utilizes reusable educational objects which are used to facilitate a particular learning goal. These can be interactive simulations, instruction videos, digital exercises, visual demos, formative assessments, etc. They are well organized and flexible and can be used to help students try out and get feedback on difficult concepts multiple times. In the context of statistics education digital learning objects can be used to explain quantitative information, statistical procedures and mathematical reasoning. A study on gamification in statistics education for health sciences learners has shown that the learning outcomes and attitudes of gamified students are better than those of other students, indicating that interactive learning methods can help overcome the challenges of statistical learning (Khoshnoodifar et al., 2023). Despite this, digital learning objects need to be further studied in learning environments specific to nursing.

With the increase of technology-based learning, there has been an increased interest in examining the educational value of technology-based learning in nursing programs.As technology-based learning has become a more common practice in education, researchers have assessed the educational value of technology in nursing programs. Digital interventions offer opportunities for flexible participation, individual learning experiences and greater engagement of instructional materials. In a scoped review of digital learning interventions in higher education, different educational applications and learning outcomes were identified, with focus on the growing use of digital resources in professional education (Sormunen et al., 2022). In the same way, comparative studies have been conducted to explore the learning outcomes and students' perceptions of nursing research and statistics education in online blended learning, flipped classroom teaching, and online teaching (Chaturvedi et al., 2023). The investigations show the importance of digital instructional practices and point to the need to consider certain resources that support learning and to identify specific learning outcomes that can be measured.

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There has also been a significant focus on learning management systems, and the use of multimedia in education in nursing. The study of e-learning environment on Moodle is also linked to collaborative learning, students' satisfaction and academic outcomes, which emphasizes the pivotal role of digital environments in educational processes (Chen et al., 2023). There have also been randomized controlled studies investigating the use of multimedia-based instruction as a means to academic achievement and students' motivation to learn in nursing education (Ongor & Uslusoy, 2023). Moreover, gamified flipped classroom has shown potential to enhance nursing students competency in their skills and motivation through interactive learning activities and structured learning strategies (Elzeky et al., 2022). The studies considered in this paper suggest that digital educational materials can be used to foster a number of facets of learning, but that these materials might not be equally effective in relation to their instructional design, content, or student engagement.

The opportunities for interactive learning in nursing have further been enhanced by emerging digital technologies. The use of mobile chatbot-assisted learning to enhance academic outcomes and self-efficacy by providing personalized learning experiences has been studied (Chang et al., 2022a). Virtual reality has also been explored in childbirth education, showing the effectiveness of virtual environments in enhancing learning performance during nursing education (Chang et al., 2022b). Furthermore, distance-based nursing skills education using online games has been tested as a distance learning strategy for teaching nursing skills (Chang et al., 2022c). Similarly, AR interventions have been explored for the teaching of leg ulcer care, demonstrating the broad range of digital teaching methods that are currently possible to nursing educators (Rodriguez-Abad et al., 2022). These technologies, however, mainly focus on clinical knowledge and practical skills, but not statistics achievement.

A review of the research literature in the field of nursing education supports the need to investigate digital learning outcomes in diverse teaching environments. A systematic review and meta-analysis of technology-based educational tools in intensive care nursing found that technology-based approaches were relevant to supporting educational outcomes (Rezayi et al., 2022). In addition, the study of blended learning in nursing education in the surgical field has also focused on the analysis of student performance and learning experiences, highlighting the possible impact of using blended learning (Li et al., 2023). Continuing interest in the evaluation of technology-supported nursing education (Li et al., 2024) is reflected in more recent systematic reviews that examined the topics of online practical skills instruction and virtual clinical learning. Similarly, virtual clinical learning has been evaluated as an educational method in nursing programs in a systematic manner (Alsharari et al., 2025). Despite these advances, the statistics learning outcomes that are achieved with digital learning objects are still rather thin.

The effects of digital instruction may also vary according to individual student attributes. Digital competencies and academic self-efficacy were investigated as factors that relate to students' academic achievement in nursing education, where technological competence could affect the

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educational outcomes (Ibrahim & Aldawsari, 2023). The role of metaverse in motivation and academic performance has also been explored as well, which reflects the significance of engagement in technology in education (Çetinkaya Uslusoy et al., 2024). However, it is important to take into account baseline knowledge, academic characteristics and participation patterns when determining whether improvements in educational performance are due to digital interventions. Therefore, the present study utilizes secondary data analysis of an existing nursing education database to analyze statistics achievement after learning-object-based teaching, and to explore influencing factors in education. The study focuses on the measurable outcomes of achievement, and is aware of the interpretive constraints of a single group pre test - post test design. The objectives of this study are as follows:

- To evaluate changes in statistics achievement among nursing students following instruction supported by digital learning objects.
- To examine associations between digital learning-object assessment scores, student attendance, and statistics achievement outcomes.
- To identify demographic, academic, and baseline performance factors associated with improvements in nursing students' statistics achievement.

2. Materials and Methods

2.1. Research Design and Data Source

One group pretest–posttest was used in this study, with quantitative data analysis performed to observe the changes in nursing students' statistics learning achievement after being introduced to learning-object-based instruction (Monge-Rogel et al., 2023). The data were collected from the public data named Data and Statistical Analysis to Evaluate the Effectiveness of LOs in Teaching Statistics to Nursing. Data consisted of demographic details, academic performance data, scores for learning objects assessment, attendance and achievement data before and after learning. The study was conducted on within-student achievement change and the relationship(s) between educational variables and academic outcomes.

2.2. Study Population and Participant Characteristics

The data was obtained from 54 secondary data nursing students from educational campuses in Santiago and Concepción, Chile. Demographic information about the participant was collected and categorized into age, sex, campus location, cumulative academic average, and scores of the institutional diagnostic assessment. The sex and campus were treated as categorical variables, while age was treated as a continuous variable. For the primary analysis, all 54 participants had both pretest and posttest achievement scores. Descriptive statistics were used to describe the characteristics of the participants to define the demographics and academic profile of the study

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participants.

2.3. Digital Learning Objects and Statistics Achievement Assessment

The educational intervention consisted of the creation of learning objects aimed at the teaching of statistics to nursing students.Learning objects were created for the educational intervention, related to the teaching of statistics by nursing students. Academic achievement was determined by pre-test and post-test scores obtained on the data set. Five learning-object assessment variables (RDA01 to RDA05) offered additional measures of performance across instructional activities. In addition, three specific learning outcomes (RAA5, RAA6 and RAA7) were measured pre- and post-instruction. These measures allowed for an assessment of the overall progress in achievement as well as the outcomes of individual learning without making the assumption that gains in achievement were only due to the intervention.

2.4. Data Preparation and Measurement Variables

The data was analyzed and arranged in appropriate statistical format from the original CSV file. Decimal numbers with commas were converted to numbers and categorical variables were coded. The main outcome was a difference between the posttest and the pretest, which represented the improvement of statistics achievement. Other factors were student age, gender, cumulative academic average, attendance, and average assessment performance for learning objects. Observations not available were detected prior to analysis. There were seven missing institutional diagnostic scores and one missing observation for RDA01 and RDA02, but no missing observations for primary achievement measurements.

2.5. Statistical Analysis

Data were presented as descriptive statistics, which were: means, standard deviations, frequency, and percentages. The Wilcoxon signed rank test and paired-samples t-tests were used to compare pretest and posttest achievement scores. Pearson correlation coefficients were computed to investigate the correlations among instructional variables and academic achievement outcomes. To determine factors that predict achievement improvement, a multivariable ordinary least-squares linear regression model was created with heteroscedasticity-robust standard errors. A p value of < 0.05 was considered to be statistically significant, and in instances where a 95% confidence interval was informative, the magnitude and precision of the observed association was assessed.

3. Results

3.1. Demographic and Baseline Academic Characteristics of Nursing Students

Fifty-four nursing students (19-44 years old; mean age 26.93 years) participated in the study. The number of female students was 85.19% of the sample, and the number of male students was 14.81%

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of the sample. The majority of participants (70.37%) attended Santiago campuses and 29.63% were at Concepción campuses. Among 47 students who had their mean cumulative academic average and institutional diagnostic scores measured, the mean was 5.81 ± 0.44 and the mean was 17.91 ± 5.17 respectively. These qualities are related to a mostly female student body and a diverse starting level of academic achievement (Table 1) (Figure 2).

Table 1. Demographic and Baseline Academic Characteristics of Nursing Students (N = 54)

Variable	Category / Statistic	Value
Age (years)	Mean ± SD	26.93 ± 7.27
Age (years)	Minimum–maximum	19–44
Sex	Female, n (%)	46 (85.19%)
Sex	Male, n (%)	8 (14.81%)
Location	Santiago, n (%)	38 (70.37%)
Location	Concepción, n (%)	16 (29.63%)
Cumulative academic average	Mean ± SD	5.81 ± 0.44
Institutional diagnostic score	Mean ± SD	17.91 ± 5.17
Institutional diagnostic score	Available observations	47
Attendance	Mean percentage	94.40%

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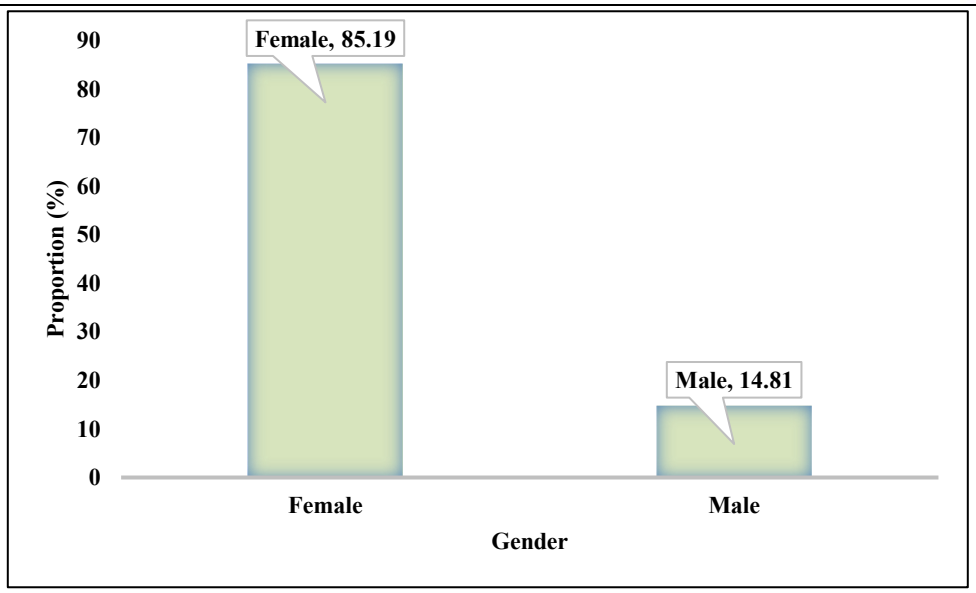

Figure 1. Gender Composition of the Study Population

3.2. Changes in Statistics Achievement Following Digital Learning-Object Instruction

The mean scores on the pretest and posttest were 8.22 ± 2.95 and 10.07 ± 5.44, respectively, with a statistically significant increase in achievement. The average improvement was 1.85 points, with a 95% confidence interval of 0.13–3.57. The difference between the two samples was found to be statistically significant using a paired samples t-test ($t = 2.16$, $p = 0.035$). This was confirmed by the Wilcoxon signed-rank test ($p = 0.049$). Individual differences were, however, quite large with 26 students gaining, 23 students losing, and 5 students not showing change in their scores following instruction (Table 2) (Figure 2).

Table 2. Comparison of Pretest and Posttest Statistics Achievement Scores

Statistical measure	Pretest	Posttest	Change
Sample size	54	54	54
Mean score	8.22	10.07	+1.85
Standard deviation	2.95	5.44	6.30
Median score	8.00	8.00	0.00
Minimum score	4.00	4.00	−12.00
Maximum score	16.00	28.00	+20.00

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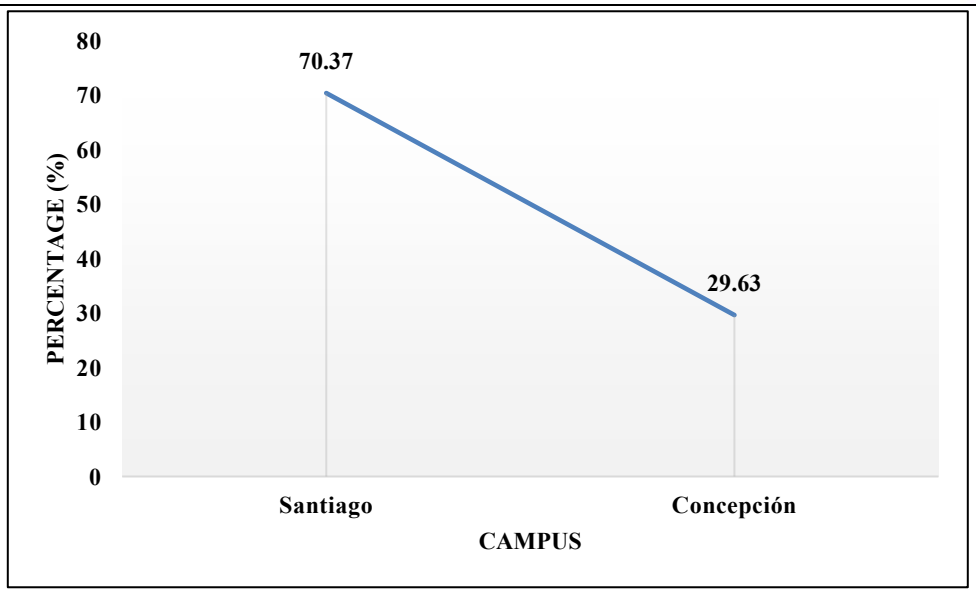

Figure 2. Campus-Wise Distribution of Nursing Students

3.3. Performance Across Digital Learning-Object Assessments

Students' performance was consistently high on the five digital learning-object assessments. With the exception of RDA04, which had a lower mean score, there was relatively little variation in assessment performance across the range of mean scores (94.44 to 97.55). The mean scores of RDA03 were 97.07, while RDA01 and RDA05 had mean scores of 95.92 and 95.55 respectively. The average of the recorded learning-object assessment was 95.39 ± 7.13. Average scores were above 100 for all five assessments, indicating significant concentration of scores at the upper end, which could limit the discrimination ability of the tests (Table 3) (Figure 3).

Table 3. Descriptive Statistics of Digital Learning-Object Assessment Scores

Learning object	N	Mean	SD	Median	Minimum	Maximum
RDA01	53	95.92	8.32	100.00	52.00	100.00
RDA02	53	97.55	6.55	100.00	70.00	100.00
RDA03	54	97.07	8.53	100.00	55.00	100.00
RDA0	5	94.4	10.	100.00	60.00	100.0

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4	4	4	89			0
RDA05	54	95.55	10.58	100.00	50.00	100.00
Recorded RDA average	54	95.39	7.13	99.20	72.80	100.00

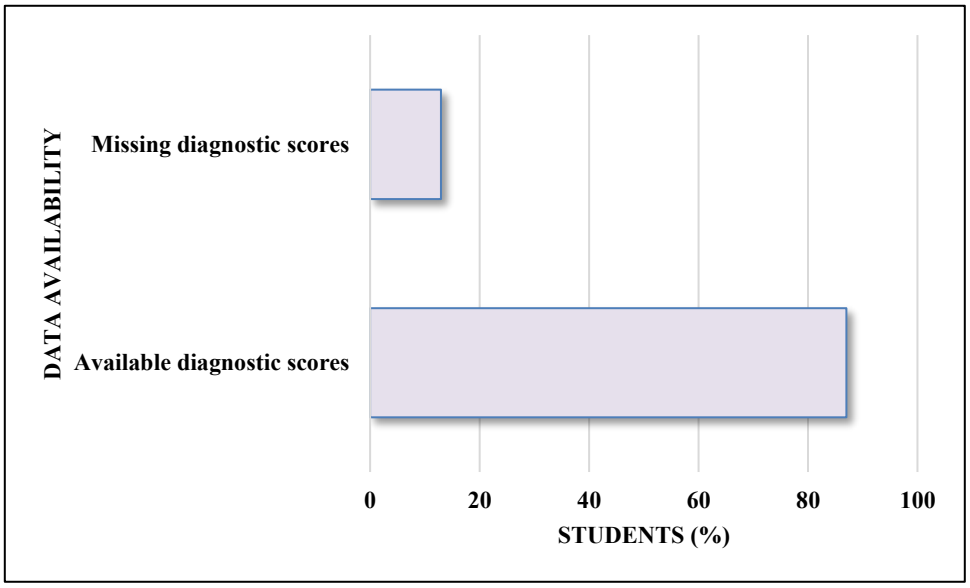

Figure 3. Availability of Institutional Diagnostic Assessment Data

3.4. Associations Between Learning-Object Performance, Attendance, and Statistics Achievement

There were no statistically significant links between average learning-object assessment scores and posttest statistics achievement ($r = -0.064$, $p = 0.647$) or achievement improvement ($r = -0.040$, $p = 0.775$) through the use of correlation analysis. Attendance was similarly unrelated to posttest scores ($r = -0.061$, $p = 0.661$) and achievement improvement ($r = -0.024$, $p = 0.862$). The baseline achievement was moderately negatively correlated with improvement ($r = -0.506$, $p < 0.001$). The overall performance in terms of the assessment of learning of the learning-objects and their productiveness in achieving the outcomes did not have significant linear relationships (Table 4) (Figure 4).

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Table 4. Correlation Analysis of Learning-Object Performance, Attendance, and Statistics Achievement

Predictor variable	Outcome variable	Pearson's r	p-value	N
Average LO score	Posttest achievement	−0.064	0.647	54
Average LO score	Achievement improvement	−0.040	0.775	54
Attendance	Posttest achievement	−0.061	0.661	54
Attendance	Achievement improvement	−0.024	0.862	54
Cumulative academic average	Achievement improvement	0.024	0.864	54
Pretest achievement	Achievement improvement	−0.506	<0.001	54

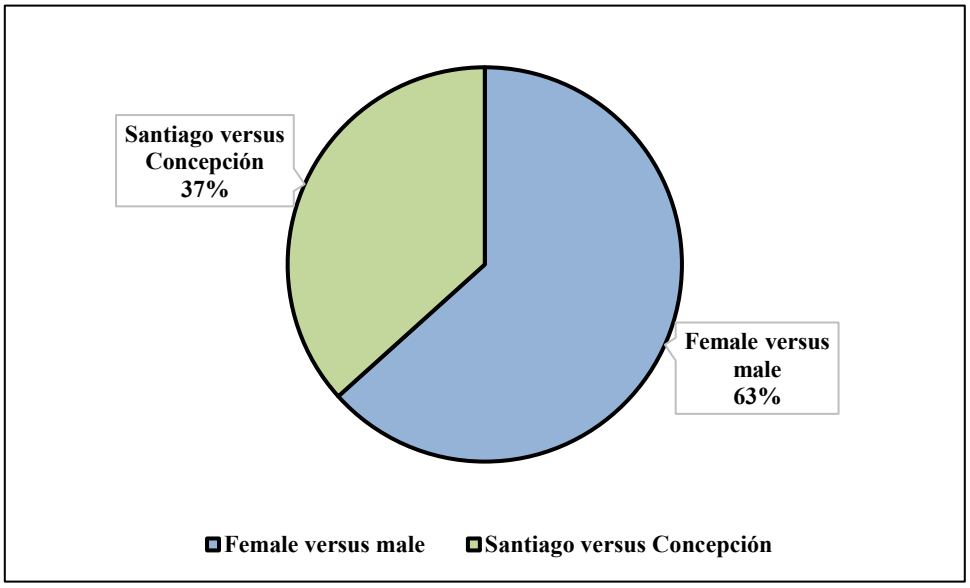

Figure 4. Gender and Campus Representation Differences

3.5. Factors Associated With Improvement in Statistics Achievement

Baseline achievement was the main statistically significant predictor of improvements over time in

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a multivariable regression model ($\beta = -1.161$, $p < 0.001$). None of the other variables (age, sex, cumulative academic average, attendance, or learning-object assessment performance) were found to have any statistically significant independent associations with achievement change. The model explained 33.5% of the observed variation in improvement ($R^2 = 0.335$; adjusted $R^2 = 0.250$). The results indicate that a relationship exists between initial achievement and subsequent score changes, but it should be viewed with caution as there is the possibility of regression to the mean and mathematical coupling (Table 5) (Figure 5).

Table 5. Multivariable Regression Analysis of Factors Associated With Statistics Achievement Improvement

Predictor variable	Coefficient (B)	Robust SE	95% CI	p-value
Intercept	19.006	21.908	−23.933 to 61.945	0.386
Pretest achievement	−1.161	0.313	−1.773 to −0.548	<0.001
Age	−0.144	0.094	−0.329 to 0.040	0.126
Cumulative academic average	2.440	2.536	−2.531 to 7.410	0.336
Attendance	−3.610	12.539	−28.187 to 20.967	0.773
Average LO score	−0.156	0.178	−0.504 to 0.193	0.381
Male sex	2.492	2.598	−2.600 to 7.585	0.337

Regression Model Summary

Model statistic	Value
Observations (N)	54
R-squared (R^2)	0.335

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Adjusted R-squared	0.250
F-statistic (robust)	5.960
Model p-value	<0.001
Residual degrees of freedom	47

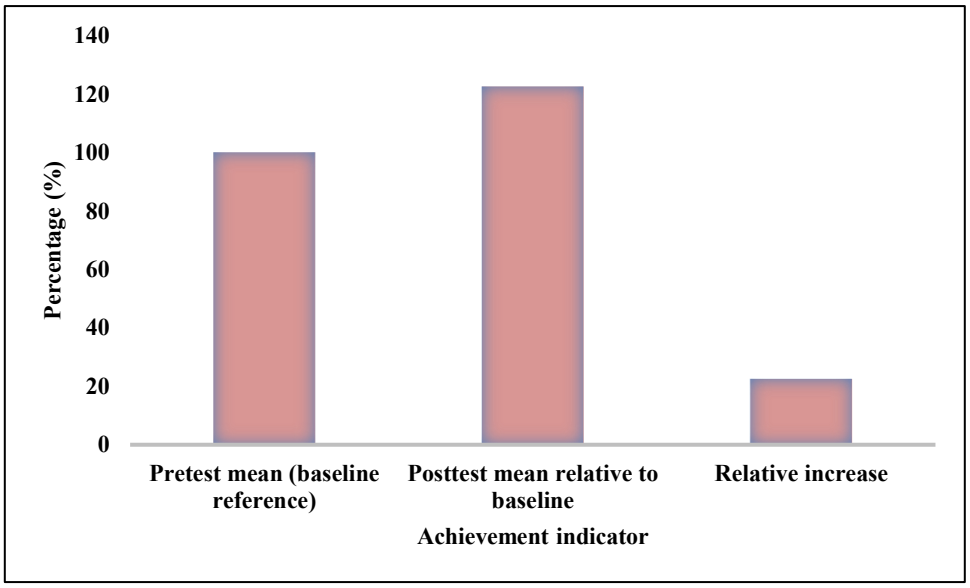

Figure 5. Relative Improvement in Mean Statistics Achievement

4. Discussion

The impact of digital learning objects-supported instruction on statistics performance of the nursing students, as well as to examine the relationship between academic achievement, learning object assessment performance and attendance. The results showed that the mean achievement scores were statistically significantly higher after instruction (10.07) than before instruction (8.22) with an average change of 1.85 points ($p = 0.035$). Although the effect size (Cohen's dz) was relatively low (0.294), the overall improvement was relatively modest. The results align with the previous studies that found that interactive learning activities in digital learning environments could facilitate higher-order thinking skills and academic achievement (Mat et al., 2024). However, the present study's result of improvement should not be interpreted as conclusive evidence of effectiveness of intervention since there was no separate comparison group.

There was a greater degree of individual differences in achievement, as 26 students improved, 23 reduced and five remained static. This variation implies that the students were experiencing different learning experiences in the same teaching method. These patterns might be due to baseline

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differences in knowledge, digital competence, academic confidence, and learning preferences. In previous studies, digital learning tools have been linked to educational self-efficacy, which suggests that psychological and educational factors can impact students' interactions with technology-enhanced learning (Saleh & AlAli, 2022). These characteristics have not been measured directly in this study but should not be overlooked because of their variability and potential importance when using digital educational resources: when studying individual learning needs.

The five digital learning-object assessments showed a consistently high performance with a mean ranging from 94.44 to 97.55. Many participants got the highest possible scores, with median scores of 100 in all five assessments. Based on these findings, students were able to be successful in the activities that were added to the learning objects. There was a lack of correlation between high attainment scores and attaining the overall statistics achievement goals, however. Al-Osaimi and Fawaz (2022) emphasize on the role of motivational approaches, instructional support, and engagement of students in facilitating their successful learning in blended learning. The current results build on this, indicating that there is no clear correlation between successful completion of the digital activities and improvements in statistical knowledge as a whole.

The correlation showed no statistically significant correlation between the average score of the learning objects assessment and the achievement of the post test ($r = -0.064$, $p = 0.647$). In the same way, there was no significant correlation between learning-object performance and improvement in achievement ($r = -0.040$, $p = 0.775$). This suggests that performance on instructional activities and performance on the whole achievement assessment might be different aspects of learning. The results of previous studies conducted on the interactive educational videos among the nursing students have focused on the areas of knowledge acquisition (Natarajan et al., 2022), practical skills (Sawyer and Gordon, 2015), and satisfaction as an educational outcome (Natarajan et al., 2022). This distinction is important because sometimes the learning object can be used as a means to accomplish a specific task without significant improvements in independent achievement assessments. Therefore, the education value of digital resources should be assessed by several complementary indicators and not solely based on activity scores.

There were also virtually no relationships between attendance and achievement improvement ($r = -0.024$, $p = 0.862$) or achievement ($r = -0.061$, $p = 0.661$) at the posttest. The findings indicate that the differences in statistical learning outcomes in the sample was not merely as a result of attendance. Attendance information may not represent depth of engagement, concept, or independent practice, etc. Differentiated instruction in evidence-based nursing education has been given a lens on making learning adaptations to students' needs and measuring learning satisfaction and achievement (Liou et al., 2023). When evaluating the contribution to education of digital learning objects, instructional participation needs to be taken into account together with more detailed measures of learning engagement.

Baseline achievement was the strongest statistically significant factor associated with subsequent

improvement ($B = -1.161$, $p < 0.001$) in a multivariable regression analysis. Overall, students with lower starting scores tended to show higher scores at the end of the course, but cumulative academic average, attendance, age, sex, and learning-object performance were not significant independent predictors. The negative correlation between baseline achievement and change scores, however, might partly be due to regression to the mean and mathematical coupling. Systematic review evidence of the effect of digital serious games on learning outcomes in nursing education has shown that educational technologies can support learning outcomes, with the effect varying depending on the characteristics of the intervention and the evaluation methods used (Thangavelu et al., 2022). Hence, these findings from the present regression should be viewed as suggestive correlations, rather than definitive evidence that specific student characteristics predict the effectiveness of interventions for improving student performance.

The results of the study have implications for the design and assessment of digital statistics education in nursing education. Although assessment scores for learning objectives are high, the overall improvement in student achievement is relatively small, suggesting a need for further development of conceptual application and assessment alignment of the learning objectives in the instructional activities. Digital literacy could be especially important due to the fact that nursing students might have varying levels of competence in using educational technologies (Martzoukou et al., 2024). In addition, surveys of serious games, gamified applications, and virtual simulation technologies highlight the wide array of digital instructional strategies adopted in undergraduate nursing education (Chatzea et al., 2024). These should be explored in future research as to whether they enhance statistical understanding through adaptive feedback, differentiated learning activities, and targeted support. More rigorous research, conducted in larger controlled settings, using validated assessments of achievement, with consistent assessments, and with detailed indicators of engagement, would yield more convincing evidence of the educational efficacy of digital learning objects.

5. Conclusion

Improving achievement of statistics by nursing students: secondary analysis of pretest–posttest educational data with digital learning objects. The results showed a statistically significant advantage in the mean achievement scores for the learning-object based instruction, but the effect was not of great magnitude. There was considerable individual variation with some pupils making more than others and educational progress not being consistent for all. While gains were high in the five digital learning-object assessments, these gains were not statistically related to the overall statistics results or improvements. Likewise, there were no significant relationships between attendance and cumulative academic performance with achievement gains. Baseline achievement was the most powerful predictor of subsequent changes in scores, indicating that there were differences in learning outcomes related to baseline knowledge levels. This relationship is however to be interpreted with caution, due to regression to the mean. The results show the need to distinguish between successful completion of digital instructional activities and statistically valid

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improvement in statistical understanding. Digital learning objects can be used as a supplementary method to improve statistics learning and may be useful to support structured learning activities. However, the lack of a control group hampers inferences about their effectiveness. Future studies should utilize more controlled studies, standardized evaluation tools, and individualized learning plans to identify the effectiveness of digital learning objects in further developing statistical literacy, academic outcomes, and evidence-based reasoning in nursing students.

Students at the undergraduate level often have learning challenges with respect to mathematical anxieties, statistical interpretation, computational processes, and unknown terms. It is important that statistics anxiety is a psychological hurdle that can present a challenge to concentration, confidence, and academic participation. There have been several findings in previous studies that indicate that students enrolled in social statistics courses are prone to feel anxious from a variety of sources (Condron et al., 2018). The relationship between statistical anxiety and students' attitude, self-efficacy, academic performance and procrastination has also been explored (Dodeen & Alharballeh, 2025). Cross-national studies also highlight the link between statistics anxiety and students' attitudes toward statistics (Korolkiewicz et al., 2025). It is known that innovative teaching methods, such as using animated microlearning materials, can be used to improve statistical learning and create positive attitudes (Huang & Janakiraman, 2025).

It's possible that the attitudes, motivation, engagement, confidence, and learning behaviors of students are correlated with their academic performance in statistics. Achievement-related beliefs and academic self-regulation are important factors in undergraduates' performance in statistics (Corwyn & McGarry, 2020). Studies that have employed structural equation modeling have examined the interrelations between statistical attitudes, mathematical competence, engagement and academic achievement (Lavidas et al., 2020). Likewise, the influence of statistical performance on attitudes has been studied as a potential mediator between attitudes and anxiety about statistics and/or academic procrastination (Lethbridge et al., 2024). In addition, project-based teaching methods have been explored in their impact on students' perceptions of the relevance of statistics (Huang et al., 2023). Taken together, these results suggest a need to consider psychological and educational aspects along with examination performance.

The present study is intended to examine students' perceptions, learning problems and academic achievement in undergraduate statistics teaching and learning quantitatively by analyzing the students' individual data. In particular, it aims to investigate students' attitudes towards learning statistics, learning problems that are frequently reported, their scores on examinations and statistical relationships between their perceptions, learning problems, and their examination scores. Further, the study will look into the factors that contribute to differences in academic achievement and present recommendations based on evidence to enhance the teaching of undergraduate statistics.

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